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U.S. DEPARTMENT OF COMMERCE
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UTILITY PATENT APPLICATION
TRANSMITTAL LETTER
UNDER 37 C.F.R. 1.53(b)

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Box Patent Application

Transmitted herewith for filing is a patent application.

Inventor(s): **Gerhard SCHNEIDER and Harald NEUMANN**

For: **PLANAR SENSOR ELEMENT**

1. Enclosed are:

- 1 sheet(s) of drawing(s).
 A certified copy of German Appln. 1 97 46 516.1-52 on which priority is based.
 Assignment of the invention to Robert Bosch GmbH.
 A declaration/power of attorney (UNSIGNED).
 An Information Disclosure Statement and an accompanying PTO-1449.

Other: _____

2. The filing fee has been calculated as shown below:

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Respectfully submitted,

Dated: 10/20/98

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PLANAR SENSOR ELEMENT

FIELD OF THE INVENTION

The present invention relates to a planar sensor element for determining gas components, in particular for determining the oxygen level in internal combustion engine exhaust gases.

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BACKGROUND INFORMATION

A conventional sensor element is described in, for example, German Patent Application No. 42 31 966 (corresponding to U.S. Patent No. 5,529,677), which is made of a composite of individual foils arranged in consecutively superimposed layers. Function layers such as electrodes, printed conductors and an electric resistance heating element are arranged between the individual foils. The function layers and the heating element are printed onto the unsintered (green) foils using screen printing, for example. Then, the foils are placed one on top of the other, laminated and subsequently sintered. In the planar sensor element of this type, the resistance heating element is arranged in one of the layers between an external cover foil and an adjacent layer structure. The resistance heating element is embedded between two electrically insulating layers (e.g., Al_2O_3), so that the heating conductor is electrically insulated from the adjacent foils. On its side opposite a side of the cover foil, the layer structure has a considerably greater thickness than the cover foil adjacent to the other side. Due to this highly asymmetrical arrangement of the heating element with respect to the layer sequence of the layer structure, the cover foil heats up much more than the layer structure provided with function layers. The non-homogeneous distribution of the heating power results in increased heat shock sensitivity of the planar sensor element when the temperature varies.

SUMMARY OF THE INVENTION

The planar sensor element according to the present invention is advantageous in that the heating power is homogeneously distributed over the cross-section of the sensor element.

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Thus, a resistance of the sensor element to temperature variations and thermal shock is improved. Furthermore, the efficiency of the heating element is enhanced.

5 It is also advantageous if a covering layer structure is made of a single foil having a thickness, in the unsintered (green) state, of 0.6 to 1 mm, preferably 0.8 mm. The layer structure adjacent to the resistance heating element on the opposite side and containing the function layers (function layer-side layer structure) has a total thickness approximately equal to
10 that of the cover foil or the cover foil-side layer structure, according to the number of foils and other layers, such as a cover layer on the external electrode. This means that the thickness of the function layer-side foils d_F for uniform thickness distribution is defined by

$$d_F = (d_{F1} - d_D) : n ,$$

where d_{F1} is the thickness of the unsintered cover foil, d_D is the thickness of the cover layer or protective layer arranged on the external electrode, and n is the number of function layer-side foils. In this calculation, it is assumed that the insulation layers have at least approximately the same thickness on both sides of the heating element.

BRIEF DESCRIPTION OF THE DRAWING

The Figure shows an exemplary embodiment of a sensor element according to the present invention.

DETAILED DESCRIPTION

The Figure shows a cross section through an exemplary embodiment of a planar sensor element 10, which may be used, e.g., for determining the oxygen level in exhaust gases of internal combustion engines or combustion systems. The sensor element shown in this embodiment is a lambda-1 sensor (e.g., a Nernst sensor). The design and function of such a sensor are generally known.

Sensor element 10 has, when unsintered, an elongated, plate-shaped design, which contains a plurality of layers arranged one on top of the other in a layer structure. The layers, when unsintered (green), are basically formed by oxygen ion-conducting solid electrolyte foils.

In this embodiment according to the present invention, sensor element 10 has an electrochemical measuring cell 12 and a heating element 14. Measuring cell 12 has a function layer-side layer structure 12' with a first foil 16 and a second foil 18. A reference channel 20 is integrated in second foil 18. A measuring electrode 22 is arranged on the measuring-gas side surface of foil 16, and a reference electrode 24 is arranged on the surface associated with reference channel 20. A porous cover layer 26 having a thickness of approximately 0.1 mm is placed on measuring electrode 22.

Heating element 14 has a heating conductor 30, embedded in two insulating (insulation) layers 28 and 29, the two insulation layers 28, 29 having essentially the same thickness. An external covering foil 32 follows first insulation layer 29. In order to seal porous insulation layers 28, 29 in a gas-tight manner, an sealing frame 34 is positioned around them, which is manufactured, for example, by printing solid electrode material on foils 18, 32, arranged on both sides of insulation layers 28, 29.

Heating conductor 30 is in a layer plane 36, centered with respect to the layer structure above or below. Due to this fact, the layer thickness of foils 16, 18 of measuring cell 12 is to be dimensioned according to the thickness of cover foil 32, taking into account the thickness of cover layer 26, or vice-versa. In this embodiment, the unsintered cover foil has a thickness of 0.8 ± 0.1 mm. The thickness of porous cover 26 layer is assumed to be approximately 0.1 mm. This results in a layer thickness for first and second foils 16, 18 of approximately 0.35 ± 0.05 mm each. The thickness ratio of

foils 16, 18, 32 remains basically preserved even after sintering as a layer thickness ratio, based on a sintering shrinkage of approximately 20%.

5 It is also possible for the two foils 16, 18 to have different thicknesses. It is essential, however, that the total thickness of the function layer-side layer structure of the sensor element, considering other layers such as cover layer 26, for example, be (at least approximately) equal to the
10 thickness of cover foil 32 or a cover foil-side layer structure used instead of cover foil 32.

0 Foils 16, 18, 32 are made of stabilized zirconium oxide, for example. In order to achieve densely sintered bonding, sealing frame 34 is made of the same material as the adjacent foils 18 and 32. Electrodes 22, 24 and heating conductor 30 are made of a platinum cermet, for example. Insulation layers 28, 29 are made of Al_2O_3 in this embodiment, an insulation layer 29 being initially printed onto cover foil 32. Heating element 30 is also applied to insulation layer 29 by printing. Finally, one-half of sealing frame 34, for example, is also applied around insulation layer 29 by printing.
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To manufacture the layer structure of measuring cell 12, the
25 two electrodes 22, 24, with the leads not illustrated in detail, are printed onto foil 16. The additional insulation layer 28 and the second half of sealing frame 34 are applied onto second foil 18.

30 The function layer-side and heating element-side layer structures thus formed are laminated with the unsintered foils using binder layers applied between the foils, and are sintered at a temperature of 1400 °C, for example. After
35 sintering, the plate-shaped sensor element with a rectangular cross section is obtained.

The layer structure described is, however, not limited to the

exemplary embodiment with a Nernst type sensor element 10. The present invention can also be used with a sensor element having more than three foils. Such a sensor is, for example, a broadband sensor in which a pump cell and a concentration cell
5 (Nernst cell) are provided instead of measuring cell 12.

What Is Claimed Is:

1. A planar sensor element for determining at least one gas component, comprising:

a layer structure including:

a heating element generating a heating power, and
a layer-shaped heating conductor embedded in the
heating element,

wherein the layer-shaped heating conductor is arranged in
a layer plane of the layer structure to obtain an at least
approximately homogeneous distribution of the heating power
over a cross-section of the layer structure.

2. The planar sensor element according to claim 1, wherein
the layer plane is centered with respect to the layer
structure.

3. The planar sensor element according to claim 1,
wherein, when the layer structure is unsintered, the
layer structure further includes:

at least two function layer-side foils, and
at least one cover foil-side foil having a
predetermined thickness, and

wherein a total thickness of the at least two function
layer-side foils is at least approximately equal to the
predetermined thickness.

4. The planar sensor element according to claim 3, wherein
the layer structure includes a further layer having a further
thickness, and wherein the total thickness includes the
further thickness.

5. The planar sensor element according to claim 1, wherein
the layer structure further includes a plurality of
electrically insulating layers, a first thickness of one of
the electrically insulating layers being approximately equal
to a second thickness of another one of the electrically
insulating layers, and further comprising:

a heating conductor embedded in the electrically insulating layers, the electrically insulating layers being formed on both sides of the heating conductor.

6. The planar sensor element according to claim 5, wherein the layer structure further includes a sealing frame surrounding the electrically insulating layers, the sealing frame having a frame thickness which is equal to a thickness of the electrically insulating layers.

7. The planar sensor element according to claim 6, wherein the electrically insulating layers include two electrically insulating layers.

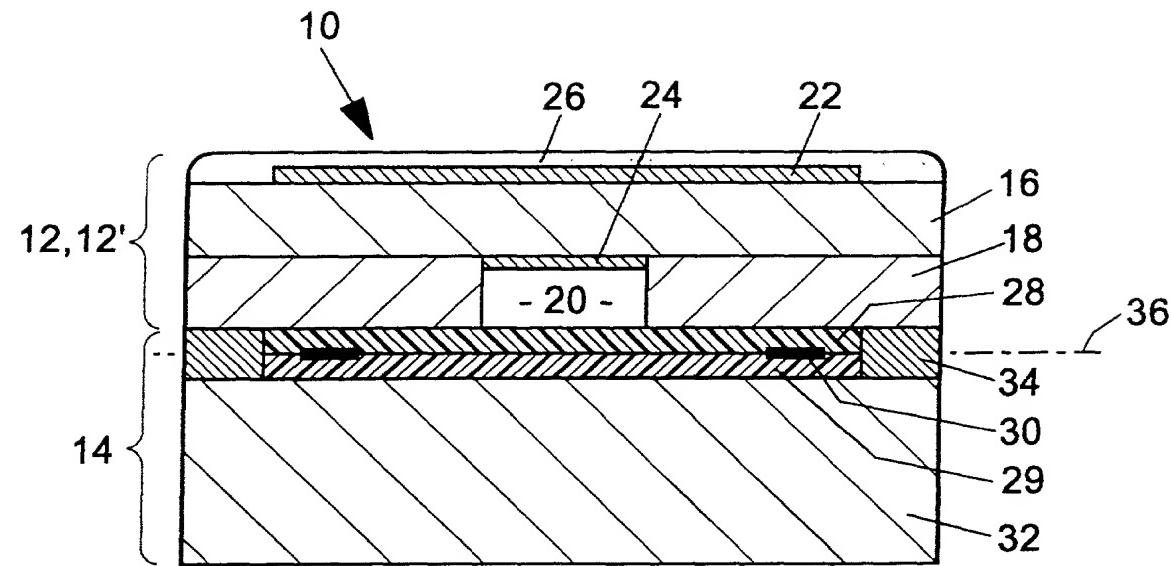
ABSTRACT OF THE DISCLOSURE

A planar sensor element for determining gas components, which includes a layer structure with a heating element integrated therein with a layer-shaped heating conductor. The heating conductor is arranged in a layer plane of the layer structure so that an at least approximately homogeneous distribution of the heating power of the heating element over the cross-section of the layer structure is obtained.

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G E P S A T I O N S



Figure

DECLARATION AND POWER OF ATTORNEY

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am an original, first and joint inventor of the subject matter which is claimed and for which a patent is sought on the invention entitled **PLANAR SENSOR ELEMENT**, the specification of which is being submitted herewith.

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, § 1.56(a).

I hereby claim foreign priority benefits under Title 35, United States Code, § 119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application(s) for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

PRIOR FOREIGN APPLICATION(S)

Number	Country filed	Day/month/year	Priority Claimed Under 35 USC 119
1 97 46 516.1-52	Fed. Rep. of Germany	22 October 1997	Yes

EL169610786US

And I hereby appoint Richard L. Mayer (Reg. No. 22,490) and Gerard A. Messina (Reg. No. 35,952) my attorneys with full power of substitution and revocation, to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith.

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful and false statements may jeopardize the validity of the application or any patent issued thereon.

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